White Clay Creek

Nutrient concentrations, flow rates, and mass loads (the product of the average daily flow rate and nutrient concentration) were examined for three stations along the mainstem White Clay Creek (Table 7). Data on the East Branch White Clay Creek collected during low-flow surveys in 1997 were also examined and compared to the mainstem data. Time series graphs of flow rates and nutrient concentrations were first developed using all the data at each station. Time series graphs of nutrient concentrations and mass loads at low flow conditions (flow rates less than the 20^{th} percentile annual flows) were also developed in order to detect any changes or trends over time. The time series graphs of nutrient concentrations and mass loads for each station are presented in Appendix F.

Table 7. Stations and data availability for the White Clay Creek low flow analyses.

Stream Reach	Gage Number	Location	Data Available
East Br White Clay above Avondale	WQN0179	East Br. White Clay below Stroud Res. Sta.	Nutrients (PA-DEP)
Mainstem White Clay	WQN0149 (01478245 and 01479000)	Strickersville	Nutrients, Flow * (PA – DEP)
Mainstem White Clay	DE-105071 (01479000)	Near Stanton Above Confluence with Mill Creek	Nutrients, Flow (DE-DNREC)

* Note: Flows at Strickersville prior to 10/1/96 were estimated based on the ratio of flow rates of Strickersville to Newark (01479000) for data after 1996. Flow rates after 10/1/96 were measured at the Strickersville gage (01478245). Flow rates estimated at the Stroud Research Center were based on the equation Qstroud=Qnewark*2.5*0.0135 which was derived from the regression of design flows at Avondale and Newark and drainage area.

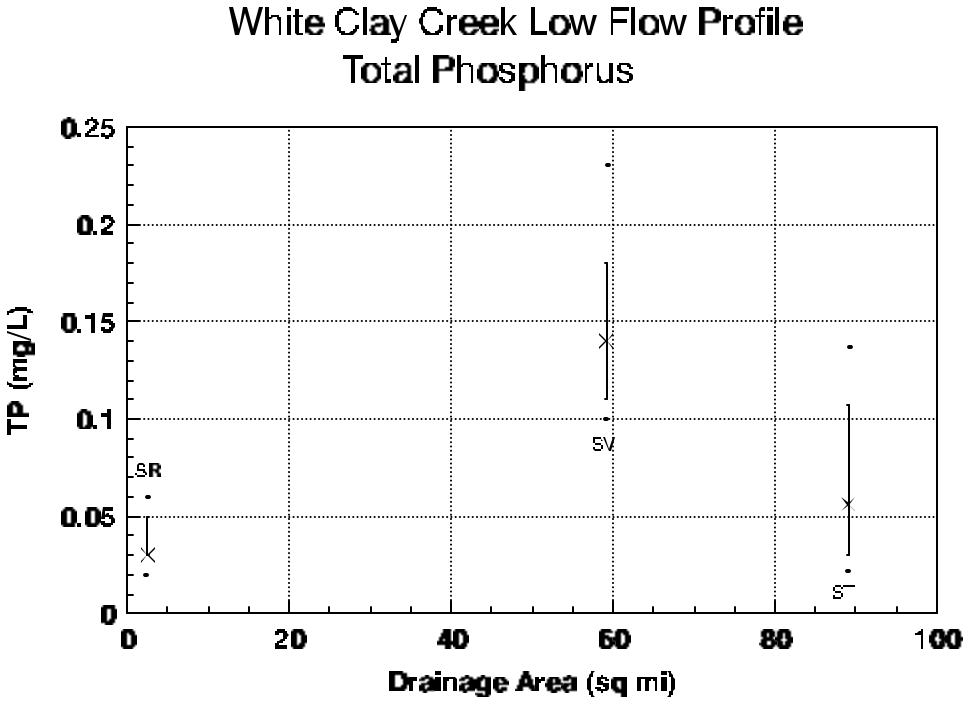
Nutrient Concentrations and Mass Loads

As noted above, the time series graphs of nutrient concentrations and mass loads for the White Clay Creek are shown in Appendix F. A Mann-Whitney test was conducted on the low flow data set to determine any statistically significant changes in concentrations or mass loads over time. The results of these analyses are summarized in Table 8 (statistically significant changes at the 0.05 level are indicated with "**"). The nutrient concentrations and mass loads were fairly stable for the stations at the Stroud Research Center and at Stickersville over the period of record (1988-1997 at Stroud Research Center, 1980-1997 at Strickersville). Statistically significant decreases in SOP and NO3 mass loads were noted at the station near Stanton from 1991-1992 vs 1993-1997, however the number of data points for the 1991-1992 data were limited. A summary of the low flow nutrient concentrations and mass loads (median, upper and lower quartiles, maximum, and minimum) at each station is presented in Appendix G.

Table 8. Summary of median nutrient concentrations and mass loads at low flow conditions for the White Clay Creek. (** denotes a statistically significant change at a 0.05 level of significance).

Station	Period	TP mg/L	TP Load lb/d	SOP mg/L	SOP Load lb/d	NH3-N mg/L	NH3-N Load lb/d	NO3-N mg/L	NO3-N Load lb/d
Stroud	88-92	0.04	0.25	0.014	0.084	0.02	0.14	3.60	23.1
Res. Center	93-97	0.03	**0.20	0.004	0.022	0.02	0.13	3.63	19.5
Strickersville	80-92	0.10	14.0	0.07	7.5	0.02	2.95	3.92	524
	93-97	**0.14	13.6	0.10	9.0	0.02	2.90	3.87	404
Near Stanton	88-92	0.12	21.6	0.085	16.5	0.05	9.7	2.44	444
above Mill Cr.	93-97	0.06	4.9	0.016	**2.1	0.03	3.3	**1.21	**136.1

Figures 29-32 show the spatial profiles of nutrient concentrations and mass loads at low flow conditions over the last 5 years along the White Clay Creek. Phosphorus concentrations throughout the watershed are relatively low, but reach their highest levels at Strickersville and decrease as the river flows through the Newark area. The phosphorus concentrations at the upstream station are probably representative of background conditions. Nitrate concentrations in the upper to middle portion of the watershed are elevated and are probably the result of nonpoint source nitrogen contamination of the groundwater aquifer providing baseflow to the stream. As was noted with the phosphorus concentrations, the nitrate concentrations decrease in the lower portion of the watershed, which tends to be influenced by more urban land uses.



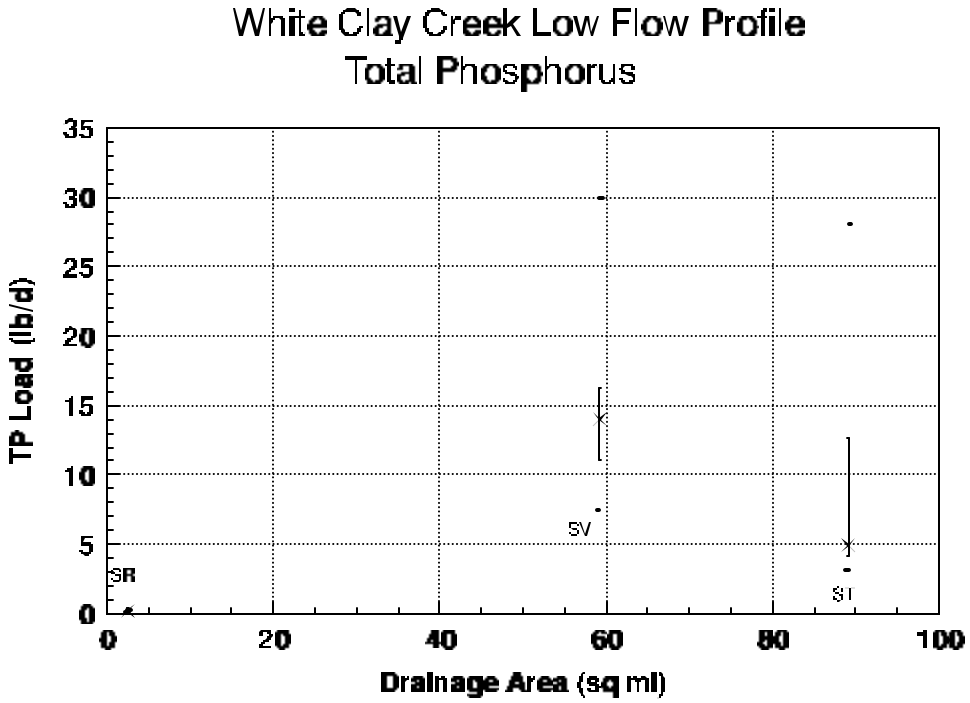
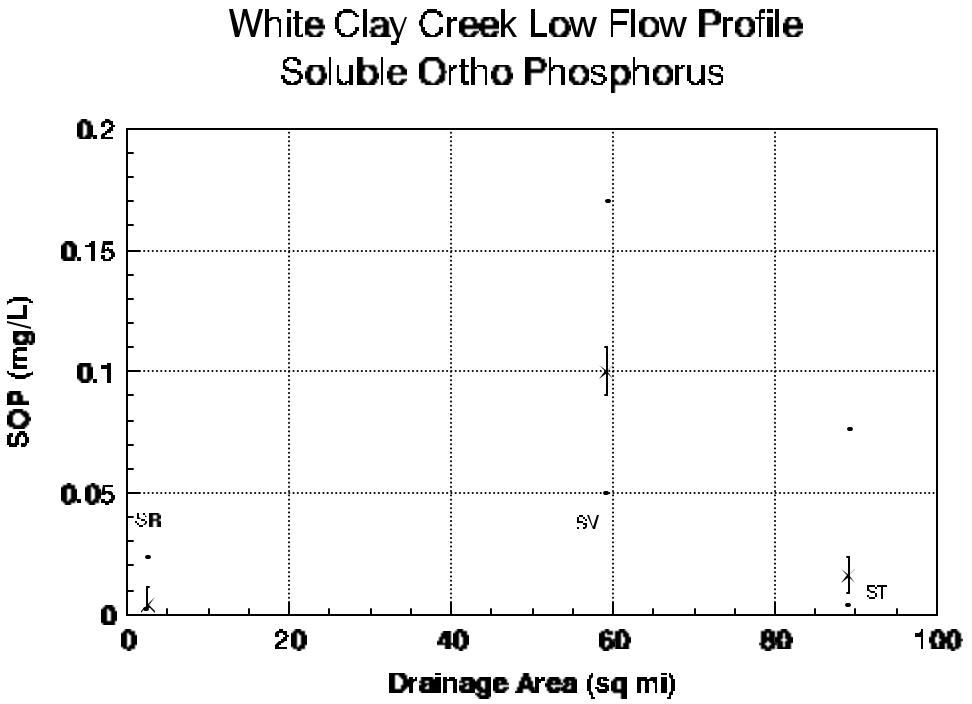


Figure 29a and b. Total phosphorus concentrations and mass loads at low flow conditions in the White Clay Creek as a function of drainage area (SR= Stroud Research, SV= Strickersville, and ST= Stanton).



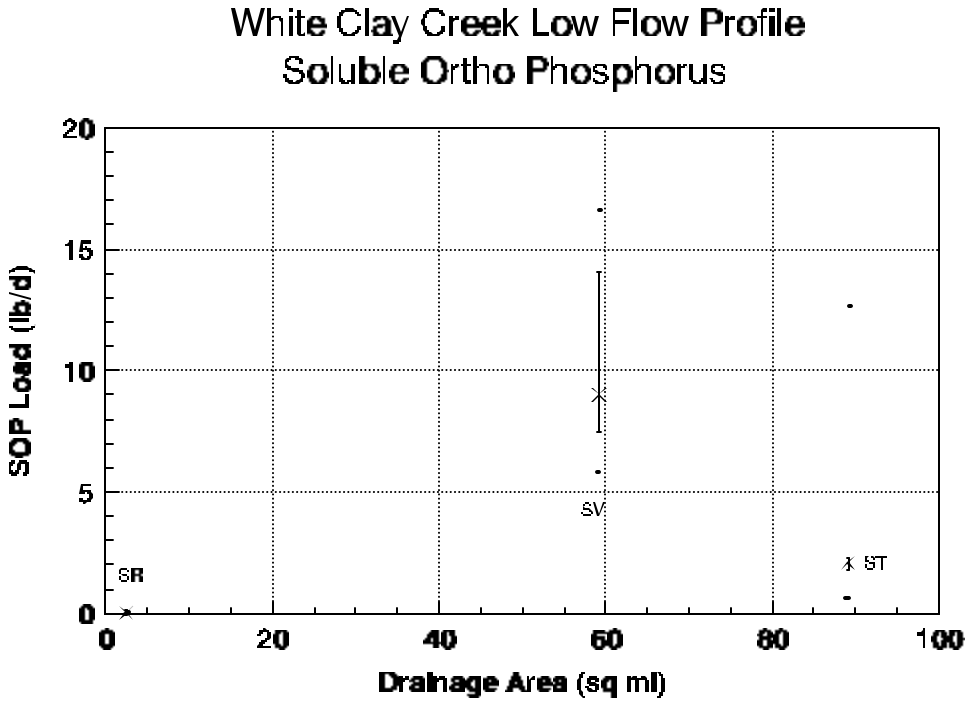
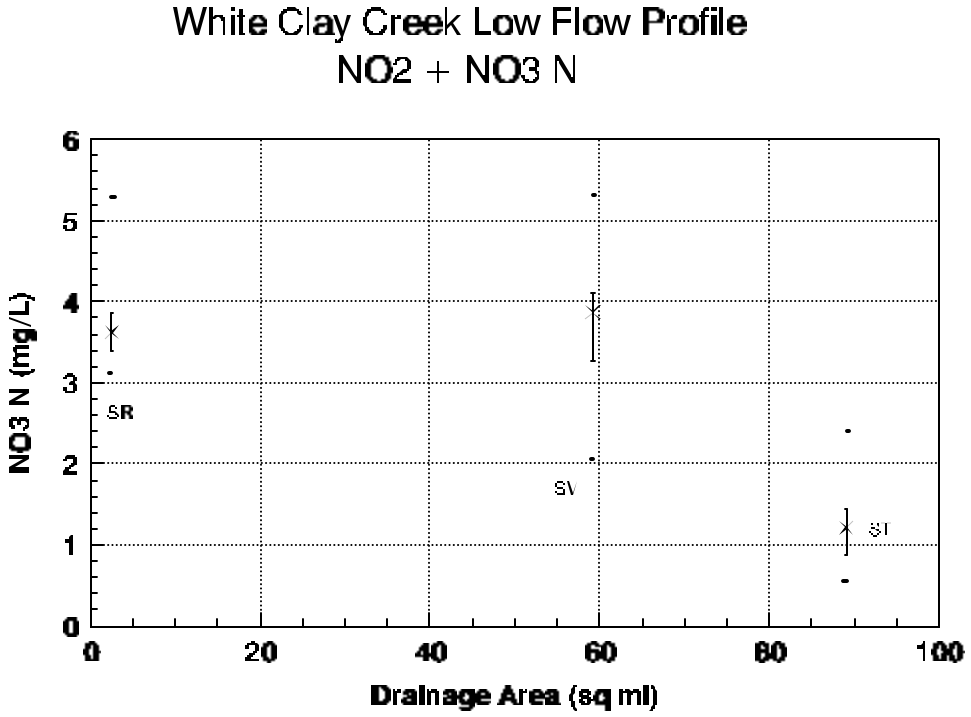


Figure 30a and b. Soluble ortho-phosphorus concentrations and mass loads at low flow conditions in the White Clay Creek as a function of drainage area (SR= Stroud Research, SV= Strickersville, and ST= Stanton).



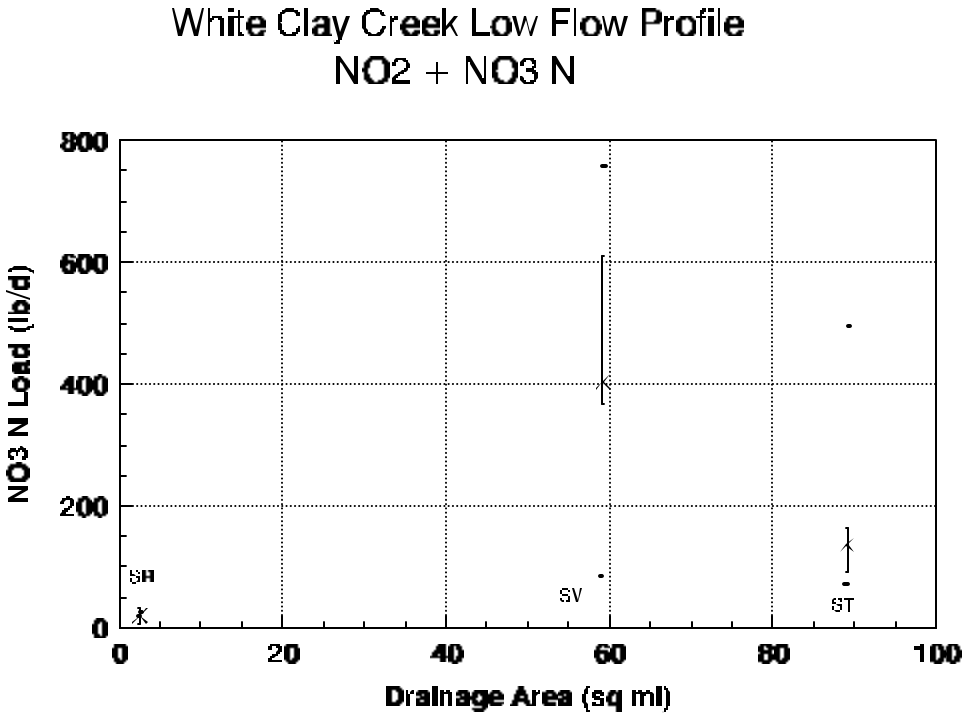
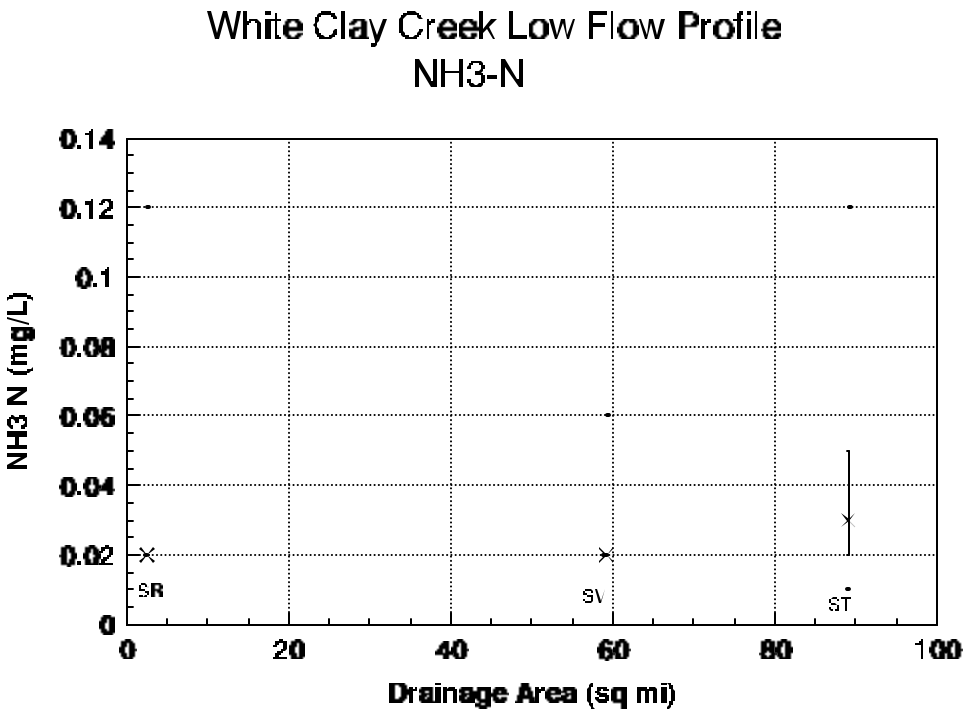


Figure 31a and b. Nitrate-nitrogen concentrations and mass loads at low flow conditions in the White Clay Creek as a function of drainage area (SR= Stroud Research, SV= Strickersville, and ST= Stanton).



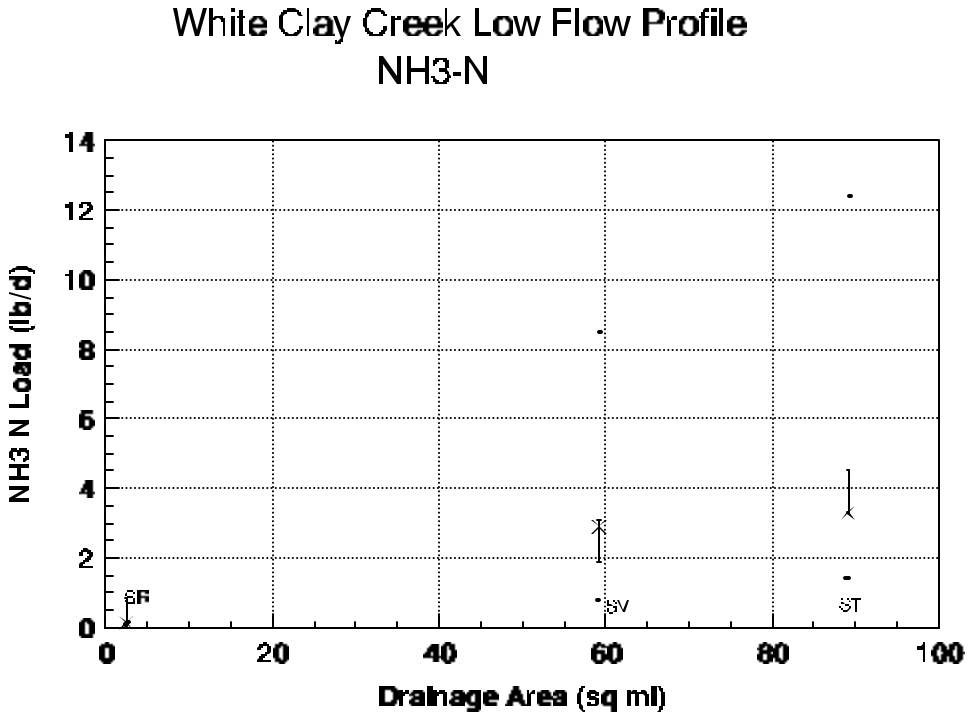


Figure 32a and b. Ammonia-nitrogen concentrations and mass loads at low flow conditions in the White Clay Creek as a function of drainage area (SR= Stroud Research, SV= Strickersville, and ST= Stanton).

Dissolved Oxygen Concentrations – East Branch White Clay Creek

The only data set of continuous dissolved oxygen data on the White Clay Creek was collected during the 1997 low flow surveys above and below Avondale on the East Branch (Davis, 1998). Continuous DO monitors were set a several stations above and below the Avondale wastewater discharge. Figure 33 shows the temporal DO profiles for a station located above the discharge (M2), a station located below the discharge (M4). The graph shows that the dissolved oxygen concentrations were not significantly different above or below the discharge. The upstream station shows significant diel variation in DO (approximately 3.5 mg/L) which may be attributed to moderate nutrient concentrations and high availability of sunlight due to limited stream bank shading. Although nutrient concentrations are higher at the downstream station, there is significant stream bank shading, which limits the sunlight available for photosynthesis in the stream.

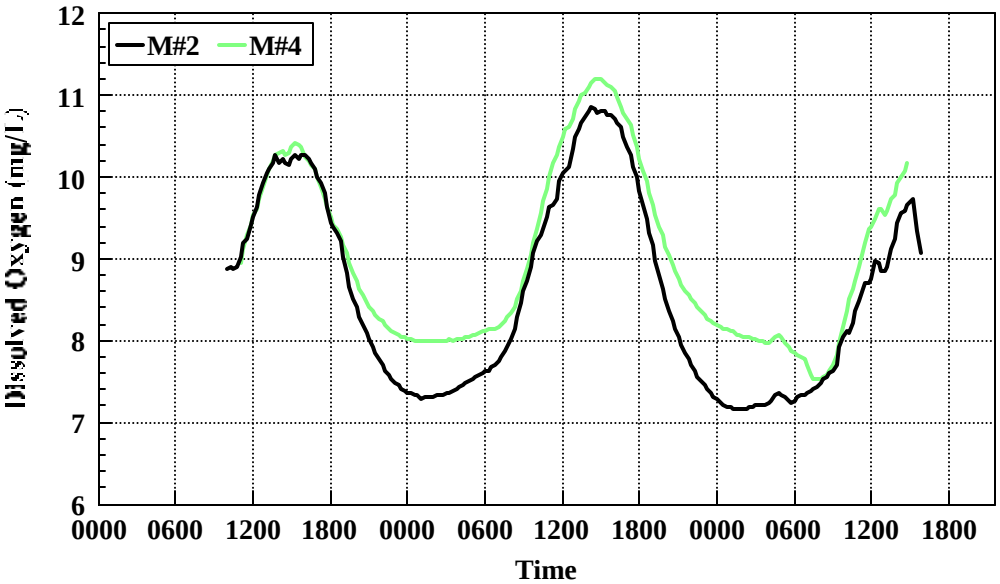


Figure 33. Dissolved oxygen profiles for the East Branch White Clay Creek above Avondale (M2) and below the Avondale wastewater discharge (M4) for 8/26-28/97.

Summary of Findings for the White Clay Creek

Nitrate nitrogen concentrations under low flow conditions are elevated in the portion of the watershed above Newark, which is likely due to nitrate levels in the groundwater aquifer providing baseflow in the river. Phosphorus concentrations are low to moderate throughout the watershed and tend to decrease as the river flows through the urban area of Newark, similar to the decrease in nitrate concentrations in the lower portion of the watershed. Continuous DO data for the East Branch White Clay Creek indicates that the DO concentrations are above the water quality criteria. Daily DO ranges of 3.5 mg/L indicate moderate photosynthetic activity, and the presence of stream bank shading may be limiting photosynthetic activity below Avondale.